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Foreword

The optimal organization of research and development (R&D) in a market economy is one of the unsettled questions of economics. R&D has great externalities that make its support more complicated than most goods in which the contrasting of private benefits with private costs in a market system approximates the social welfare. Thus, the organization of R&D becomes a key issue in a transition to a market system of a former centrally planned economy. This is particularly so for the USSR[1], which has been a major source of science and technology.

Recognizing its importance, Deputy Prime Minister Laverov approached the International Institute for Applied Systems Analysis (IIASA) to initiate collaborative work with the USSR State Committee for Science and Technology and the USSR Academy of Sciences on the topic of ***Research and Development Management in the Transition to a Market Economy*** in the autumn of 1990. Dr. Peter de Jánosi, Director of IIASA, and Professor Merton J. Peck, Leader of the Economic Reform and Integration (ERI) Project (also IIASA), met the Deputy Prime Minister to discuss such a cooperation.

The collaboration began with a meeting in November 1990 organized by IIASA with the support of the Committee for Systems Analysis of the USSR Academy of Sciences. This meeting explored the feasibility of creating an IIASA research activity on the impact of economic reform and transition upon the organization and management of science and technology in the USSR. An agreement was reached that IIASA would participate in an activity with the USSR State Committee for Science and Technology concerning *R&D Management in the Transition to a Market Economy*. This activity would be led by Professor Richard Levin from Yale University and Dr. Sergei Glaziev from the Central Economic and Mathematical Institute in Moscow.

The second conference held on this topic, cosponsored by the USSR State Committee for Science and Technology and IIASA, and organized with the International Center for Research into Economic Transformations (Moscow), was an outgrowth of discussions with representatives of the USSR Academy of Sciences, the State Committee, and the Center in January 1991. IIASA was invited to arrange a meeting in which the numerous issues involved in the restructuring and organization of scientific and technological activities in the Soviet Union could be discussed in systematic ways. Soviet experts prepared papers dealing with the Soviet Union's present situation and reform plans regarding R&D management. These papers were presented at the Conference and commented on by a small group of economists, engineers, and R&D managers from the United States, Europe, and Japan.

The Conference, held in Moscow in July 1991, provided an exceptional opportunity to review and discuss science policy in a economy making the difficult transition to a market system. The new data and ideas for changes in the Soviet science and technology sector were of great interest to experts from West and East. The discussions resulted in a commitment to longer term research on an extended list of topics. More about the future plans can be read in the corresponding section of this paper.

The author of this summary of the Moscow Conference is indebted to all participants, particularly those who took the extra time to read and comment on drafts of this paper. However, this review represents the author's interpretations and any omissions or inconsistencies are his own.

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[1]The names USSR or Soviet Union used in this paper refer to the area previous to August 1991, which is now termed as the *former Soviet Republics*.

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Introduction

The development of an appropriate science and technology policy is one important aspect of the Soviet movement away from a centrally planned system to a market economy. R&D policy will impact on other economic, political and social changes and, in turn, will be altered by all the changes made elsewhere.

Experts from the Soviet Union believe that science and technology management in the USSR must become responsive to demand, flexible and, in one way or another, profit oriented. In the past and largely still today, Soviet R&D has been a part of the large non-market sector. Present government plans and actions provide for the creation of a market for research and technology. Great urgency is attached to such a goal. The fact that each market economy is unique to a certain extent provides a number of alternative approaches for the integration of R&D into a market economic system. Soviet policy-makers and scientists are looking toward western industrialized market economies to gain an understanding of how to deal with research and development in a market environment and, still more fundamentally, how to prepare the science and technology community of a command-type administrative economy to respond to a market system.

The present situation in the USSR with respect to science and technology policy is both revealing and interesting. Soviet science is regarded as a unique cultural system. Due to the crumbling and disappearance of the economic and political system that maintained it, the scientific community in the USSR is left largely to fend for itself. The goals of Soviet policy-makers and scientists lie in promoting the transition to a market economy, while preventing the collapse of one of the world's largest R&D communities. The current disproportions arising in the still mainly administratively dominated system underline the urgent need to reorganize the science and technology sector and the policies that regulate it. The growing imbalances are the result of:

1. concentration of resources in obsolete industries,
2. the availability and distribution of financial resources for R&D,
3. a large technology gap between military and civilian sectors,
4. the relatively low share of the private commercial sector in economic activity,
5. distorted and conflicting incentive structures (i.e., for enterprises, branch ministries, etc.)
6. high level of vertical integration in industry, lack of inter-industry supply relationships or other cooperation, and loose economic ties between real technological demand and performed R&D,
7. absence of adequate intellectual property rights,
8. monopolization, barriers to entry, and a lack of participation in the international market with outputs and inputs (i.e., technology),

9. interbranch and interorganizational barriers between research institutes and staff in industry, higher education, and the Academy of Sciences, and
10. an inappropriate tax system, collapse of the state budget and state promotion of R&D.

This is not an exhaustive list of the issues, but it does give some indication of the immense reconstruction required to promote the sustainability of market-oriented technology development and science policy. Many Soviet experts agree that a new, much more flexible, techno-institutional market structure is essential. This structure must introduce aspects of competition, stimulate the supply of innovations and their diffusion while simultaneously allowing demand stimuli from the economy to influence the innovators and researchers, allow a blending of domestic and global R&D priorities, and facilitate a longer term perspective for R&D investors. Unfortunately, the threats of mass unemployment in the scientific community and other sectors, increases in emigration of domestic experts, the uncertain path of conversion of the defense industry for civilian purposes, the regression of the once all-round, high international scientific standing, the deterioration of the precise potential upon which a modern growth economy depends, and the waste of intellectual resources paint a gloomy picture for future Soviet economic development if something suitable is not soon done about the science and technology sector.

Soviet policy-makers and scientists are particularly concerned about these issues due to their relevance to the future potential of the whole economy and the success of the general reform effort. The transition to the market brings with it many prospects, but also problems. A delicate balance of policies must be found in order to, at least to some extent, secure the currently available R&D resources to provide a basis for economic growth as well as productivity and efficiency increases, while simultaneously subjecting them to market forces. Thus, the key questions that must be dealt with are: how the present R&D community can be integrated or transformed to be an integral part of the new techno-institutional market structure and how this will proceed during the economic transition of the Soviet Union?

Numerous experts, from both East and West, indicate that the answer lies in the appropriate *management of research and development in the USSR*. And this was precisely the topic which was the central theme of the conference summarized in this paper.

The Conference (consequently also this paper) focussed on five topics. These were:

1. R&D in the Soviet Economy
2. Case Studies of Soviet R&D
3. Technological Change in the Soviet Union
4. Prospects for Restructuring the Institutions of Technological Change
5. Plans for Further Research

As the Conference program in the Appendix indicates, each session encompassed presentations by Soviet experts based on previously prepared papers and corresponding remarks to these papers by Western discussants. What follows is a short description of key points elaborated in the presentations and a summary of the discussions on each topic. The meeting provided a frank and open exchange of ideas and the opportunity to see data previously unavailable to researchers in the West. Further information on this topic and this activity can be obtained from the Economic Transition and Integration (ETI) Project at IIASA.

R&D in the Soviet Economy

The Presentations:[2]

There is a goldmine of information in the three papers prepared for this session of the Conference. Western experts could only be impressed by the openness and generosity of information that was made available. Much of it had not yet fallen under the scrutiny of Western observers and was often not all too familiar amongst the Soviet colleagues themselves. The papers offer an insider's view of the origin and present situation of science and technology in the USSR. On the one hand, the authors are not reserved in their criticisms of the past management of research and development, while, on the other, they consistently emphasize the available potential and ability that can ensure the survival of the science and technology sector throughout the rough time of transition to an economy dominated by market forces. The paper by Gokhberg and Mindely, *Soviet R&D Resources: Basic Characteristics*, enables Western researchers to construct a clearer picture of Soviet R&D based on up-to-date and reasonably comparable data. In order to set the stage for the summary of the discussion, let us now turn to a short review of a number of the essential points presented.

[2]Refer to the conference program in the Appendix to find details about the titles of the papers presented and their respective authors.

The origin of the present structure of science and technology policy is the same as that of the State which it serves. Political goals, which had priority in such a system, caused the evolution of science to be frequently determined by factors of national prestige rather than the true needs of economy and society at large. The result has been the rise of a socio-economic phenomenon called *"branchdom"*: division of the economy into separate, rather isolated, sectors. By the end of the 1930s when the centrally planned system (CPS) was in full swing, all production decisions including R&D and long term development issues were taken from the authority of industrial enterprises and transferred to higher management levels (i.e., Ministries and State Committees).

This practice made it difficult for the consumers of R&D products to influence the field, effort, and funding of research through channels typical of a market economy. The scientific community was forever attempting to utilize its bargaining power to influence these elements, though with distorted results. Thus, branchdom cultivated scientific monopolies that distorted the goals of technological progress. This led to a structure in which mainly large-scale R&D institutions, often with many thousands of employees, were most viable. A limited number of rather small-scale institutes, directly serving some ministerial directives, also functioned. In the period between 1975 and 1985, while the government imposed strict restrictions on the process of establishing new R&D institutions in fear of losing control, the average size of a R&D institute grew by more than 25 %. Furthermore, the CPS has been the prime culprit in creating strong inter-branch and inter-organization barriers that prevent information exchange between scientists in research institutes and staff in industry, higher education, and the Academy of Sciences.

Basic and applied research are separated from one another by organizational autarky of Industrial Ministries and the Academies of Science. R&D plans for different departments of the CPS were determined by corresponding bodies in the Central Committee of the Communist Party, the State Planning Committee, the Military-Industrial Commission, and the State Committee on Science and Technology. Other than in military-industrial R&D, inadequate coordination led to mismanagement and conflicting indicators and objectives. There was a continual conflict between enterprises' and branch ministries' planning perspectives and the actual duration of technological development from research and development through to implementation and diffusion. Additional barriers between

the Academy, educational institutions, and industry (as well as between industries) split the scientific community into different groups with weak communication and under strict regulation. Therefore, the early 1980s saw the structure of the Soviet R&D sector as extremely monopolized (with discretionary distribution of R&D resources depending on quality) and exceptionally inflexible and unable to respond to new demands of society and science itself.

Despite periodic showings of scientific achievement, the 80s were a time of decline for Soviet R&D: stagnation and an ever-widening gap between the rate of *intellectual production* to that in the industrialized countries had become the distinguishing features[3]. Estimates predict that the gap has grown from 10-15 years behind in the mid 1950s to 20-30 years in the mid-1980s, and still growing (Glaziev and Motorygin, 1991, p.8).

In their paper *Economic Reform Impact on Soviet Research and Development*, Glaziev and Motorygin emphasize that this situation compelled authorities to introduce *Perestroika* in the science establishment with the proclamation of a Government Decree on "The Transformation of Research Organizations on the Basis of Complete Self-Accounting and Self-Finance" by USSR President Gorbachev in the fall of 1987. According to this Decree, state research institutes receive some autonomy with respect to the formulation of research plans and the access to alternative sources of finance. The ministerial organizations and monopolies in the R&D sector were to be abolished and prices on R&D products liberalized. Simultaneously, the State Enterprise Law (SEL) and subsequent self-organization were advocated and implemented, the price setting mechanism for R&D products ceased to be the domain of the State, and limits to the size of personal income from R&D activities were abandoned. These elements facilitated the blossoming of a non-

[3]The rate of growth in the numbers of R&D personnel in the 1980s frequently dropped below 1% per year, whereas it ranged between 3-5% in the USA during the same period. The figures below indicate the much slower relative increase of R&D specialists in the USSR as compared to the USA throughout the 1980s (Gokhberg and Mindely, 1991, p.5).

Number of specialists engaged only in R&D, USSR & USA
(as of January 1, thousands)

	1981		1986		1989	
	USSR	USA	USSR	USA	USSR	USA
specialists	1434.2	1258.7	1599.4	1725.5	1654.6	2026.9

Note: US figures do not include consulting personnel.

state R&D sector dominated by an unprecedented increase in R&D cooperatives that employed more than 320,000 persons and accounted for more than 3 billion rubles worth of work and services in 1989 (refer to Table 1). R&D activity seemed to become biased toward contract work to improve the quality. Such an emphasis will not rejuvenate the R&D sector as explained in the discussion of the presentation below.

Table 1. R&D expenditures of non-state organizations (bln. rubles)

	1987	1988	1989	1990	1991[a]
total expenditures	0.03	1.2	4.7	6.0	6.15
including:					
R&D Cooperatives	0.01	0.17	3.15	3.9	4.0
Youth Research Centers	0.02	0.85	1.1	1.45	1.5
permanent research teams of Union of Science and Engineering Society	[b]	0.12	0.35	0.5	0.5
permanent research teams of All-Union Society of Inventors	[b]	0.07	0.1	0.15	0.15

Note: (a) estimated, (b) insignificant or unavailable.
Source: Glaziev and Motorygin, 1991, p. 20.

Unfortunately, reality revealed that real shifts in the structure and quality of R&D activities failed to keep pace with the scale of the *financial revolution.* Conditions conducive to stimulating the demand for highly efficient and science-intensive production had not been created; one of the most critical being the absence of a well-defined intellectual property rights system, which inevitably impaired the ability to capitalize on R&D achievements. Many private firms began to resort to a type of *industrial piracy* that involved using and selling inventions and know-how developed by state organizations; the main form was the by-now legal, part-time employment of specialists fully employed by the state. Estimates show that more than half the scholars in the Soviet Union work in the non-state R&D sector, while many continue to be employed by the state (Glaziev and Motorygin, 1991, p. 15). Thus, these firms were no more than intermediate service agents that do not carry the burden of maintaining the equipment, infrastructure, and national obligations of a state research institute. Essentially, knowledge and technology was consequently transferred between research institutes and from these institutes to the production sector, but did not stimulate R&D activities. Whether revenue from the sale of these intellectual products is reinvested in R&D remains doubtful. In fact, numerous non-state R&D enterprises are consequently, indirectly subsidized by the state and may not be economically viable in a more competitive market without access to such resources.

The unavoidable weakening of central control over state enterprises (due to the implementation of the SEL) was accompanied by the decline of performance and enterprise promoted R&D. With the subsequent introduction of the new tax system, ministries lost the rights to collect any portion of state enterprise profits, cutting off an important source of industrial R&D funding.

In the paper entitled *Transformation of Basic Structures and Operating Mechanisms of Soviet Science*, Piskunov and Saltykov cover most of the issues mentioned above and add a special account of the worsening situation throughout 1990 and early 1991. Industrial R&D was plagued by financial trouble due to the abolishment of the special industrial funds for science and technology development (distribution method of subsidies for R&D when regulation required all profits to be transferred to the state), the new 1991 tax system (including federal, republican, and local taxes on state enterprises' profits), the decreased profit leading to reduced demand for state R&D products by industrial and agricultural enterprises[4], collapse of the state budget[5], and the *brain drain* from the state research institutes to the emerging private sector[6]. In addition, more simple aspects such as the obsolescence of much experimental equipment and scientific instruments accompanied by the general deterioration of research premises are taking their toll on R&D advances. Finally, the opening of the Soviet economy has exposed previously protected areas of Soviet science and technology to levels attained in the international community, often revealing substantial gaps between the internationally publicized and the actual domestic research achievements. This is particularly true for the civilian sector.

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[4]Already in 1988, the share of enterprises engaged in industrial R&D rose from 51.2% to 66.4% (Glaziev and Motorygin, 1991, p. 17).

[5]Particularly in the case of basic research concentrated in the Academy and the Military Industrial Complex (MIC), which were largely dependent on state subsidies. In 1991, state budget revenues fell by as much as 70 % (partly accentuated by the *War of Laws* between the different levels of government). Expenditures on R&D in the MIC fell, in nominal terms, from 15.3 billion rubles in 1989 to 13.2 in 1990. With a 19% inflation rate in 1990, the real decrease is approximately 33 % (ibid, p. 11).

[6]13.5 % of R&D is carried out in the non-state sector.

The Discussion:[7]

The presentations on the topic of *R&D in the Soviet Economy* revealed the enormity and complexity of the task to appropriately manage this factor that is at the core of the relationship between science and technological growth. Management of research and development in the USSR is characterized by a conflict between political, national, and historical priorities (competing at all levels of science and technology), and countless distinct cultural and regional peculiarities. Although the economic transition has been recognized as necessity and reality, the existing influences appear to adhere to an excess devotion to maintain all institutions and employment in R&D, including the applied area. Different solutions are required in both the basic and applied areas.

Two major factors differentiate Eastern and Western R&D systems. They are:

1. The origin of basic research. A great portion is done in the special research institutes of the Academy of Sciences rather than in the higher education institutions. In this sense, the Soviet system resembles the French system most of those in the West. Generally, there are different mixes in the West, but determining the precise mixture for the USSR R&D community is, perhaps, not the most crucial issue at present.
2. The role of the enterprises. In the planned economic system, industrial R&D was not the responsibility of enterprises' management. If *Perestroika* proceeds and competition is established through demonopolization and privatization, the present system will prove to be infeasible and the number of free standing or independent industrial research laboratories will diminish because the industrial enterprises will themselves take up the research. Building a R&D laboratory into the enterprise allows the firm to work effectively and in a proprietary fashion with the laboratory to reduce the actual needs for formal legal instruments (as patents) in order for companies to best appropriate their returns.

[7]The discussants in this session were Ben Martin, Richard Nelson, and Luc Soete (refer to the conference program in the Appendix for details). Additional comments were made by Otto Keck, Roger Levien, Richard Levin, and Merton J. Peck.

The organization of science often reflects the organization of the economy. The differentiation and separation between fundamental and applied science is a crucial policy issue. This has direct implications for the distinction between basic and commercial R&D. The latter depends not only on the quality of R&D personnel. In a market economy, resources for applied R&D are allocated by the market mechanism in a decentralized manner responding to market forces. Resources for basic research are largely supplied by the government. Thus, a review of the experiences and literature on the integration of science and technology in a market economy would seem in order before considering policies that can propagate a simple division of R&D activities into non-profit (fundamental) and commercial (applied).

Research and development, like the general situation in the USSR, is confronted with a lack of interactions by users at economic, societal, and regional levels. In analyzing Soviet R&D, three criticisms can be distinguished that have not been uncommon in the West. First, technological progress in the USSR has been characterized as proudly originating largely from its own roots. This influences the manner in which scientists and engineers solve problems, often far from economic reasoning, particularly in the short term, as it is unnecessary to start most investigations for new innovations or inventions from scratch in today's international scientific community. Second, science has habitually neglected the market influence of societal demands. Science and technology (S&T) appeared to be more imposed on society in the centrally planned economies (CPEs) than in the West. S&T were based much more on social integration in Western than in socialist society. It is considered by some to be a paradox that a capitalist based system has led to a better quality of life. Third, a major problem was the branch system or monopoly, which has been previously discussed in this paper. While management of S&T in the Soviet Union is rapidly becoming increasingly obsolete causing significant inefficiencies and unproductiveness in the economy, the advanced western industrialized countries are building new systems with technological growth potential.

Soviet science and technology policy could have a more relevant and applied perspective for dealing with issues concerning the management of R&D if the following initiatives were undertaken:

1. Conversion of the defense-oriented R&D to concentrate more on civilian issues. This is, at least to a some extent, beginning to happen. Additionally, there is a need for simultaneous commercialization and privatization of the state MIC that can make conversion effective.
2. Directing a portion of the scientific effort towards specific areas that are less sensitive to short term price changes so that valuable resources and potential will not be lost.
3. Closer interaction with other policy areas. Science does not operate in a vacuum, so it should not be isolated from but integrated in society and economy facilitating the liberation of creativity and the encouragement of exchanges and reviews.
4. Closer ties with user needs. These make R&D effective. If R&D is linked to industry in a more competitive environment, it is consequently tied to user needs.
5. Actual integration of R&D into industry in order to link it more closely to the production process and eliminate administrative and bureaucratic inefficiencies and barriers. This implies a need for the development of more in-house research.

With regard to the time horizon of R&D activity, an increased devotion to short term projects causes the squeezing out of relevant long term research. Furthermore, the question concerning the portfolio of R&D has been a contentious issue in the West, and is now and will continue to be so in the Soviet Union. The rise of the independent industrial research laboratory owned by the firm in the West, was to separate some of the scientists and engineers from short term work. A typical example of the structure is a central laboratory (dealing with longer term issues) and decentralized laboratories that are closer to production, doing shorter term, demand oriented work. A final note related to timing, the R&D community in the USSR is struggling to accommodate economic reform and not the other way around.

Numerous comments were made with respect to the statistics that were presented, their value, comparability and meaning. The information provided indicated the need for major restructuring in the field of R&D statistics. Before any policy decisions are made, it is crucial to have a clear and undistorted picture of the existing situation (i.e., R&D

performance and potential). There is a need for modern and comparable statistics because the historical data collected are the product of the old institutional structure and were normally presented in isolation. The new Soviet style is to rely heavily on surveys, but whether these generate the best results, particularly because so much depends on who is filling in the questionnaires, is uncertain.

As a result of traditionally inflated numbers coming from the Soviet Union, there is much interest in the precise definitions of the measures reported. For example, whether only full-time workers are included in R&D employment, who is actually classified as a scientist[8], what exactly distinguishes a higher educational institution, what should or should not be included in material and technical resources and so forth. The meaning of certain indicators must also be clarified. For example, the age of equipment leads to questions of whether they were *state-of-the-art* when purchased, or an increase in graduate students may not have as positive an increase as first thought if, as in the US, there is a strong influx of foreign students (indicating that the number of domestic students may actually be decreasing while the total is increasing). Finally, the key will be a successful restructuring of R&D categories to best allow domestic analysis and international comparisons (possibly on a value basis). A first step may be to compare the definition of Soviet categories or indicators with those defined in the Frascati Manual and routinely used in OECD countries.

Case Studies of Soviet R&D

The Presentations:

This session gave Soviet experts the opportunity to describe the research and development situation in a number of selected industries. These included chemistry, metallurgy[9], and computers[10]. A special case study on the development of regional scientific centers was

[8]In the United States, while only 35 % of scientists are directly employed as R&D personnel, 45 % are employed in related activities. These make an essential contribution to research development and growth without being immediately associated with R&D. They are involved in marketing, communication, exchange programs, etc.

[9]*Organizational Setup and Implementation of Applied R&D Projects in Metallurgy* by A. A. Nikitin and V. G. Bobylyov.

[10]In two papers by L. Malkov entitled *Survivability of the Soviet R&D Sector: Computer Industry Case Study* and *Eight Shifts in the Soviet Software Industry and the Future of the Computer Industry*.

also presented in the paper *Perspectives on the Development of Regional Scientific Centers: The Town of Obninsk* by Yurlov, Sorokin, Sklyar and Gonnov. Most descriptions primarily alluded to the difficulties within the sectors[11], the obstacles to creative, free and market determined R&D, and the apprehension associated with domestic and international competition. The distribution between centralized and decentralized R&D was mentioned in light of the regional problems of technological progress.

The Discussion:[12]

Western discussants questioned why and how the science and technology sector was able to grow so large in the presence of such formidable obstacles. Obviously, there were political and ideological goals at the foundation, not those of the economy or the market.

The recent decline of R&D financing must be seen as a process of weaning the R&D sector from state dependence. Market forces inevitably result in a dilemma; no success without failure. But the uncertainty incorporating the risks of failure and the benefits of success provide precisely the incentives required for competition. On the whole, Soviet state enterprises have not shown sufficient initiative. Thus, private entrepreneurs may do better in striving for survival. In the case of computers, it appears that a great market for specialized and tailored software exists in the USSR; while having the best technology will only be part of the success required to achieve market share, others are development, service, marketing, and so on.

Science and technology is a mixed system in most western economies. The key is to move the research into an innovation quickly so that it can enter the market soon in order for the benefits of the product to be available. In the steel industry, for example, the producers themselves develop the research due to inter-industry competition (this is referred to as suicidal R&D, but if they do not do it, their competitor will). While the decrease in Soviet state funding has been accompanied by an increase in contract funding,

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[11]These included the absence of a clear system of property rights, apparent hostility to intellectualism, restrictions to professional advancement, poor communication (both physical and personal), profiteering and speculation, and so on.

[12]The discussants in this session were Richard Levin, Franz Moser, Merton J. Peck and Thomas Richardson (refer to the conference program in the Appendix for details). Additional comments were made by Richard Nelson.

the quantity of research contracted out in the West is kept to a minimum. The Western combination of in-house and external R&D is a perfect example of the mix of market and planned economics: internal R&D is more part of planning rather than market because the risk is high, there is uncertainty that often makes contracts unenforceable, and once much has been invested in a project there is a desire to preserve that continuity. Soviet policy-makers should proceed with caution when attempting to directly apply present western standards with respect to R&D management in any industry or sector because many are undergoing transitions in the West. It would be preferable to aim for longer term goals rather than short term advance that would only close in on a current level that may prove to be obsolete by the time it is attained.

A short discussion on the prospects of transition for the regional scientific centers (also referred to as science towns) revealed similarities to company towns with one employer in a market economy. In North America, many of these towns have undergone transitions, successfully building up new opportunities, while others have become *ghost towns* with the inhabitants moving elsewhere to find employment. The market forces were the essence of their future.

Technological Change in the Soviet Union

The Presentations:

The Soviet economy is characterized by profound structural and technological imbalances. Both the substantial discrepancy between administrative management methods (regulation) and the innovation processes, and the economic, ideological, and socio-cultural peculiarities have resulted in an economic and political system indifferent to innovation and technological change. Excess bureaucracy and ineffective state regulation have been identified as main obstacles to innovation. The five main factors cited as those most inhibiting innovative ability of the centrally planned system are state control and militarization, waste and shortage economy (including the so-called *anti-innovation branch structure*), monopoly and *"monotonous organization"* of innovations, economic culture, and technological incompatibility[13].

[13]From the paper *Responsiveness of Soviet Economy to Scientific and Technical Innovations: Comparison with World Experience* by Ageev and Kuzin, 1991. The authors also rather thoroughly cover the Western literature on technological change as it pertains to the Soviet situation.

The CPS signified total state control of economic life, including science and technology. Success was measured by the fulfillment of plan assignments and not by making scientific discoveries. The result has been a prevalence for short term interests (to meet the directives) rather than adaptive, long term commitments that could secure a more certain future. The long term orientation that has existed was one that remained inflexible and concentrated on old problems, thus becoming obsolete in the course of a modernizing world. In addition, investment, research, and technological policy was essentially dependent on the state budget. Any decisions with respect to these issues had to clear numerous hierarchial levels. Management of R&D financing and selection of particular paths of scientific and technological progress were, until recently, largely beyond the authority of the individual enterprise or association. On the whole, Soviet S&T progress has consistently had a substantial military/space orientation[14]. This was accompanied by a lack of devotion to economic development problems (including a disregard for creating national competitiveness), a severe neglect of the civil sector, and more direct consequences such as monopsony situation, distorted prices, and secrecy. The militarization of R&D is a threat for the future of S&T progress in the Soviet Union due to the significantly weakened channels of converting advanced technology for use in civilian industry and the rigid command management of enterprises in the military-industrial complex (MIC).

Paradoxically, the output orientation of the administrative system has, in the long run, led to a shortage economy. In the CPS, science and technological policy was restricted to the framework of the acceleration principle and had no real stabilizing role. This acceleration was sporadically initiated when central authorities became aware of a widening technological gap between the level in their country and those it was to be competing with. Of course, the huge shortages characteristic of the Soviet economy directly impeded S&T progress. Physical limitations impose on the scope of R&D, financial resources are scarce, and efforts to satisfy everyday needs divert crucial energy and creative potential. A product of such an economic system is the so-called *anti-innovation branch structure*. Its awkward and archaic character is primarily due to a lack of restructuring with respect to changing demands (particularly in the 1970s and 80s to become more R&D intensive), the inadequate development of various related services, and

[14]In 1989, 15.3 billion rubles were spent on defense-oriented R&D in the USSR. This amounted to 71% of the state allocations for scientific activities.

a high degree of obsolete capital stock[15].

The artificial type of Soviet monopoly based on administrative principles is clearly an obstacle to innovation and technological change. Insurmountable vertical economic barriers are a direct consequence of the departmental monopoly (*"branchdom"*). Soviet monopolistic management has led to degradation of product quality, lack of competition (especially to spur S&T progress), and a reduction of consumer choice. Both monopoly and monopsony features bias technological change and impede modern economic growth. Thus, there is little possibility for integration and inter-disciplinary activity. Nevertheless, ministries had the duty to maintain the given technological level of production according to predetermined state standards and to demonstrate technological achievements to the state authorities. In order to fulfill this purpose, the ministries had a pool that included not only plants and factories, but also research institutes, design bureaus, and laboratories, all somehow linked to industry. These are referred to as science/production agglomerations, which were ignorant to market impulses and processes due to their monopoly positions. Unfortunately, lobbying of the individual elements was strong, coordination between them was weak, and enterprises were generally quite unreceptive to innovations in any case.

Certain features that normally motivate R&D and subsequent technological change and innovation in a market economy are not present in the economic structure of the Soviet Union. These include a functional capital market (as well as venture capital[16]), high labor mobility[17], and international cooperation in research and exchange of scientists. The closed nature of the centrally planned system and the commitment to secrecy imposed extensive limitations on mobility of skilled personnel, and the transfer of information and technology.

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[15]Estimates indicate that between 25% and 50% of the production machinery is obsolete and that annual repairs cost over 40 billion rubles in the engineering industry and employ tens of millions of workers (Ageev and Kuzin, 1991, p.9).

[16]Venture capital is an important source of R&D financing, particularly for smaller enterprises or entrepreneurs, in market economies. High capital mobility, competition between financing sources, and a sound credit and financial system contribute to the opportunities for successful advances in science and development for parties that might be excluded from the conventional type of simple, traditional financial allocation of a command system.

[17]Soviet personnel policies in the R&D field, which were based on hierarchy, secrecy and autocracy, caused problems with respect to the stimulation of creative work, the real active participation rate of skilled personnel, scientific and technological progress, and the democratization of the S&T sector.

The prolonged domination of the CPS has resulted in the formation of a special Soviet economic culture. Among the major items influencing successful technological change was the aversion to competition and entrepreneurship, and the ignorance of the value of individual innovative spirit. Entrepreneurship was commensurate with exploitation, parasitism, and speculation. The use of ideological regulators of economic development and the existing planning and evaluation system of the results of scientific and technological activities led to an unprecedented *"paper entrepreneurship"* in the form of exaggeration of quality and quantity of results, and a trend toward spectacular projects with sensational results.

Decades of command control, largely insensitive to changing demands, have resulted in incompatibility with technological standards of market economies, with the exception of few selected strategic areas. International R&D cooperation is vital for domestic technological progress and scientific competition that reflect the evolution of demand in a modern society. Reverse engineering was one of the few links that Soviet scientific and technical experts had to the international S&T community. This peculiar research method was particularly popular in the motor vehicle, aircraft, chemical, and micro-electronics industries. It was simply engaged in to organize production and not for the long term improvement or development of technology. Although there has been some trade in licenses, much of Soviet technology imports were merely of the turn-key style that limited further domestic development and expansion. The direct import of knowledge and exchange of established or aspiring scientists was minimal.

In his presentation, Leonid Kosals comments that Soviet science continues to be plagued by the afflictions of the past (in his paper *R&D Organization and Innovation in Industry in the Transition to Market*). He adds that the current situation is progressively deteriorating due to the dismantling of all the traditional Soviet institutions and a sharp drop in the state demand for scientific products, which is then far too insufficiently compensated by the R&D demands from enterprises.

In order to illuminate the problems regarding personnel, financing, organization, research quality, contacts with clients, and measures to reform the R&D sector, Kosals has surveyed a sample of leading scientific personnel (managerial level) from laboratories, departments, and institutes in three branch science and research institutes. Results

indicated that 66% of the respondents identified the lack of financing (including sources of financing) as the main obstacle that scientific organizations face. While 62% want independent organizations with no superior body, only 22% hope to preserve the existing hierarchial style. More than half of the respondents see absolutely no advantages in having R&D institutes subordinate to ministries in the future. Although 64 % are in favor of converting the institute into a joint stock company, most admitted to a lack of knowledge and experience for performing such a change. Basically, the majority of the respondents are prepared to take the following four essential measures to reorganize their institutions to procure viability in a marketizing system: (1) independence from ministerial jurisdiction, (2) reform the ownership situation and intellectual property rights, (3) enhance performance, particularly by dismissing unproductive personnel, and (4) organize promotion and advertising for projects. This done, two-thirds of those polled are optimistically looking forward to the future, while only 18% expect a deterioration. Less than half are pessimistic about the development of demand for scientific products in the transition.

Finally, the last presentation of the session expressed that the state strategy for S&T development has been aimed at achieving international leadership in certain spheres of human knowledge, often at the expense of economic efficiency (following the Mikerin and Kozlova paper: *Technological Assessment Problems in the Transition to Market Economy*). There was more emphasis on the support of large scale technological programs than on creating a favorable economic climate for innovations and technical change. The assessment of the effectiveness of new technology in the Soviet Union revealed contradictory results with respect to the contemporary global trends. The causes hereof were the distorted, expenditure-based central pricing system, central distribution of resources, artificially suppressed consumer prices, high state taxation of excess profits (practically negating reinvestment possibilities), low wages, and comparatively high prices for new technology. Consequently, it appears that the present and future cost of innovating is far higher than the potential return and an enterprise is better off to adhere to the traditional technology. On this premise, enterprises will never be motivated to engage in technologically progressive activities.

The Discussion:[18]

The Soviet economy appears to be the most monopolized in the world of industrialized nations. Soviet innovation is a function of the bargaining process and is associated with rising inflation. In comparison, western innovation is identified with falling prices as a result of reduced costs brought about by the diffusion of the innovations. The following four factors are essential to successful innovation in the West:

1. Industrial R&D is largely financed by firms and done in the industrial laboratories owned by firms. The R&D must be done in facilities that are directly responsible to management.
2. A competitive approach to technological change. The presenters identified monopoly (the failure to have a competitive industrial structure) to have hindered innovation. Thus there is a need to restructure in order to encourage competition. A look at the industries with great growth and clear technological progress in the West reveals that they have all been characterized by avid competition. A diversity of approaches to technological change developing simultaneously is an essential element that generates technological change in a market economy. Competition is required to provide incentives (i.e., the threat or risk of failing, not to mention the sweet taste of success).
3. Scientists and engineers enjoy freedom to move. Mobility is essential for creativity. Communication is required in generating a proper structure conducive for innovation. Of course, too much mobility is deleterious for the firm's innovative activity due to proprietary reasons.
4. University research plays an important role in industrial innovation in the West. The usual mechanism is people in industry identifying the needs that would be profitable and then reaching back to science for the answers. Thus, it is need and demand driven rather than science driven, though science facilitates finding the solutions.

[18]The discussants in this session were Akira Goto, Otto Keck, Ben Martin and Richard Nelson. Refer to the conference program in the Appendix to identify which paper each discussant commented on. Additional comments were made by Richard Levin, Merton J. Peck, and Luc Soete.

The Soviet Union cannot simply look toward contract research to solve the non-market problems of the S&T sector. There is a need for a move toward in-house research. The fact that Soviet R&D laboratories are, in a way, disconnected from manufacturing presents a real problem. A possible solution may be to divide them up by assignment and subsequently allow the market to direct the labor to those fields in demand.

Some of the problems that plague the R&D community in the USSR are not unique and, therefore, should not be viewed so pessimistically. Inevitably due to the market environment that is at its basis, Western science does not have an overall, coherent, concentrated, and organized unified quest for truth; rather, there is an intense individual sense of competition. This competition may not be without costs. But the advantages of dissemination of scientific results are very great in the West, and thus it is actively inspired. In this light, the results of the Kosals survey, which showed R&D managers to favor decentralization, private ownership, mobility and other aspects of reform, are encouraging and display courage and ambition on their part. On these grounds, the outlook for Soviet S&T becomes more positive.

The area of international technology transfer is important and will gain in importance as the process of transition to a market economy continues. The emphasis on the export of technology is understandable due to the need for hard currency, but a more appropriate policy orientation would have the emphasis on technology imports. This will bring the necessary results for long term modern economic growth if the surrounding environment is receptive. The current need for foreign currency should be secondary to the effort to build up internal welfare based on domestic economic growth. Some experts contend that the more technologies can be imported, the faster they will grow. Their technological balance of payments will be negative, but the trade balance could be running a large surplus (as in Japan, Germany, South Korea, Taiwan, and others). Other problems (i.e., hard currency) will be solved in the long run, but some strategic vision from the state on R&D imports can be helpful immediately (particularly where problems may arise with respect to the financial limitations of enterprises).

Prospects for Restructuring the Institutions of Technological Change

Presentations:

The first two contributions of this session stressed not only the quality and potential of the military industrial complex (MIC) in the USSR, but also the urgent need for its conversion to civilian uses before the resources may be lost[19]. The MIC is the sector with the highest technological level because non-economic priorities such as the arms-race, desire for military supremacy, and others have led to a concentration of the most qualified personnel, state-of-the-art machinery and equipment, and enormous investments. This was done at the expense of the non-military industry[20]. Times have changed. Global disarmament and the pressure to restructure the domestic economy have forced decision-makers to actively undertake measures to begin conversion of the military industry to civilian uses.

Conversion is a complicated process anywhere; more so, of course, in the Soviet Union where the defense sector was highly monopolized, isolated from the market, shrouded in secrecy, dependent on generous budget allocations and military orders, and had no independent marketing relations or functions. The transformation of the military orientation is particularly difficult in the case of large, specialized scientific organizations (with a large proportion of fundamental R&D established on an expensive and often unique experimental base), and *closed zones* or *towns* (where an entire geographic locality and its population has been devoted to the research, design, and production of specific military paraphernalia).

Technological spin-off into the civilian sector has been negligible in the past. Aside from the military related grounds for this condition, additional, more practical reasons exist, such as no common system of coordination of new technology transfer, no financial or prestige rewards for transfer, insufficient return to enterprises making costs of implementation too high, and so on. A State Program for Defense Industry Conversion

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[19]*Defense Research and Designing Institutes in the State's Program of Conversion* by Y. N. Kulichkov and *Technological Crisis and Conversion of Military Industry* by Y. V. Yakovets.

[20]Total state expenditures for R&D were 37.8 billion rubles in 1988. 75% of this was designated for use in the MIC (Yakovets, 1991, p. 2).

until 1995 has been approved. The goal is to reorientate a substantial amount of R&D resources from the MIC towards civilian purposes. Almost 46% of the R&D resources of the defense sector should be implemented for civilian purposes by 1995, compared to only 29.6% in 1989.

At the outset of the reform process, certain legal support must be secured to encourage innovative activity and to provide an orderly market system with definite rewards for innovators[21]. Until recently R&D organization and financing was centrally planned and administered in command style. There was no room or desire for individual achievements, incentives for results, or unplanned creativity. Neither was there the potential of individual financial benefit from a discovery, nor was there any way of protecting it from free state distribution. The state was sole financier of R&D, thus also sole owner of scientific results. There have been no intellectual property rights, patents, copyrights, trademarks, or royalties comparable to those in market economies. Therefore, appropriate legal instruments and framework must be available to realize S&T growth during the transition to a market economy, and thereafter.

Administrative management routine has suppressed the scientific community in the USSR. The key words associated with the transition to a market economy, such as decentralization, democratization, commercialization, privatization, competition and reorganization, indicate the need to eliminate or sweepingly restructure the institutional framework that has generously provided funding and stability for the R&D sector for decades, distancing it from the true requirements of a market oriented society.

This is the essence of the paper by Glaziev, *Prospects of Soviet R&D Restructuring*, in which he emphasizes the need to change the whole paradigm of R&D organization, which was based on the fulfillment of state directives and non-market criteria for performance. His bold proposal for restructuring includes: integration of the processes of reorganization of research institutes and the privatization of state enterprises, dissolution of ministries and other administrative supervising bodies, restructuring of the state system of R&D finance and promotion, introduction of appropriate intellectual property rights legislation

[21]This is the central topic of the paper *Legal Support of Innovation Activity* by A. B. Vengerov and A. A. Alexandrov.

and state innovation policy, and reform of the education system. Sufficient demand for R&D products will be necessary for R&D restructuring to be successful and to make the sector viable throughout and after the transition to market conditions. Thus, demonopolization and the development of competition is a key prerequisite. There is some fear that privatization is presently taking place in the Soviet Union without demonopolization. The transformation of state enterprises into self-managed, joint stock companies can easily be followed by the rebirth of new organizational monopolies in the form of associations, conglomerates, and others.

Research institutes cannot be privatized like enterprises. The appropriate form should depend on the character of research activity, whether basic, applied, developed, or any combination of the three. The reorganized institute may remain in the hands of the state, or be transformed into consortiums owned by firms, firms' R&D departments (i.e., previously scientific-production unions), small high-tech firms, centers for contract R&D (mainly only for applied R&D), self-managed organizations leased or owned by their employees, or transferred to universities or colleges. The transformation of research institutes must be accompanied by restructuring of the present R&D financing system. Although foundation or other private funding may be established, there will probably be a need to subsidize some R&D (particularly fundamental) during the transition in order to preserve accumulated R&D potential. The recipients for how much for how long must be carefully identified.

The obstacles that hinder the realization of radical attempts to restructure include a shortage of resources (due to the distortion caused by fixed prices), lack of expertise and experience, inadequate structure of state bodies, and insufficient international exchange. A new national industrial policy is required to provide sufficient stimuli for enterprises with respect to long term investments, innovative activities, and foreign trade. Both price and quality competition should play an essential role in determining the route that research and development managers will take in the future.

The Discussion.[22]

Conversion of the military industry is a common and widely discussed topic in Western industrialized economies. Countries like Japan or the USA have gone through quite extensive conversion programs in the past[23]. The conversion can come from above in the guise of a centrally planned conversion, or it can come from below when each enterprise seeks its own destiny. The latter, decentralized manner was typical of the USA. In Japan, conversion was sudden, but goals of the ensuing policies were to facilitate competition with an early emphasis on serving the world market with domestically developed products. Conversion from below is usually more successful because it produces products and technology that the civilian sector is demanding. The reorientation from the defense to the civilian sector has great potential due to the big backlog of demand for civilian products which has arisen during the decades of concentrating on military production.

The Soviet Union has many assets that can be provided through conversion and the transition to a market economy. Many firms of the defense ministry are already producing a number of civilian products, primarily because no civilian firms engage in such production. Also, this great nation has a very well educated and highly trained population, particularly in the fundamentals. The West will need to provide assistance in certain areas such as education (exchange of students, scholars, managers, etc.) and technological agreements. Knowledge is more important than equipment (and much cheaper because it requires less foreign exchange) in the long run when the purpose is to build up domestic S&T potential.

In developing the appropriate environment for progressive R&D the presentations referred to the construction of legal support for innovative activities. The law is to be a facilitator rather than a barrier for R&D. It is difficult to provide a complete legal structure for research, development, innovation, and diffusion. This structure must be adaptable and

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[22]The discussants in this session were Alvin Klevorick, Roger Levien, Richard Levin and Merton J. Peck (refer to the conference program in the Appendix to identify the papers assigned to each discussant). Additional comments were made by Akira Goto, Ben Martin and Richard Nelson.

[23]In 1945, the USA had to undergo a much larger conversion than that facing the Soviet Union. At that time, approximately 40% of US GNP was devoted to defense. In Japan the large military sector, which was built up during WWII, disappeared overnight after the war.

flexible as more is understood about the innovative process. Of course, providing model forms of contracts and legislation is valuable, but scope must be provided for adaptation and evolution of such documents.

Preservation of the rights of individual scientists is very important. The individual inventor may not play a big role alone in developing innovations, but his role in an R&D enterprise is and will be crucial. There is a definite need for support for the intellectual labor market. There is no question that the concept of property rights must be clarified. Different industries use different methods in appropriating rewards from R&D such as secrecy, lead time, patents, and others. Market orientation gives enterprises alternative modes for appropriation and there may be a lesser role for the more formal methods (i.e., copyrights, patents, trademarks) as would be expected ex-ante.

It is ironic to observe that in the transition of the Soviet Union to a market economy, it is Lenin's question that we face: *What is to be done?* The paper by Glaziev moves us a considerable distance in thinking about this question.

As a consequence of the discussions, there seems to be agreement that basic, fundamental R&D will need support in the transition and thereafter. There is no economy which relies entirely on private funding in this area. It is the nature of basic research that it investigates not directly profit-making areas, in which firms (profit oriented in a market economy) tend to underinvest. Applied research should be primarily funded by the private sector with the exception of private R&D that are aimed at or tailored to specific national preferences (i.e., defense), and in areas where goods are not really traded in the market (i.e., health, environment, ecology, and others)[24].

Funding becomes a key issue in the transition as there may be inadequate demand for applied R&D during this stage of development. The danger of insufficient private sector demand is the potential loss or destruction of valuable human capital (research teams, etc.) that may be very productive in the future Soviet economy. These may be the beneficiaries of some transition (temporary) subsidies.

[24]This is representative of the organization of R&D funding in most market economies.

A diversity of organizational forms is ultimately desirable. The same organizational form is not necessarily appropriate for all types of S&T activities. Many western experts are strong advocates of the view that the market should select appropriate organizational forms, but the market can only achieve such a solution with a decentralized style of laboratories and institutions with a variety of alternatives. Therefore, some science and/or industry might be quickly integrated into a new system, while others may stand alone for some time. Let it be re-emphasized that even if one believes that R&D done within the manufacturing enterprise will become the dominant organizational form, engaging the existing laboratories in contract R&D activities is likely to be a viable route during the transition if market forces are allowed to operate in full. It may prove to be tough for laboratories to be absorbed into firms, because they may want to enter manufacturing directly. The latter is just another route the market provides. For market purposes, it is irrelevant whether the laboratories buy enterprises or vice versa.

In returning to the problem of inadequate demand for R&D products during the transition, it appears that the applied field will face more difficulties than the basic area, though both will need some forms of support. It may prove to be unavoidable to continue a similar magnitude of (only) financial support from the state budget to basic science as was the case in the recent past. This must be accompanied by simultaneous, substantial changes with respect to establishing principles of competition for funding, competing sources, peer review, expert assessment for determining national priorities, and so on. Applied research presents a more formidable problem. Assistance will be required in the interim, but if too generous it can deter and defer the development of competition, innovation, and the benefits thereof. Transitional subsidies may make sense, but the new tax described in the Glaziev paper might accomplish the same results. The operation of the tax should be studied more closely to determine whether rules that govern the tax distort, in any way, the laborarories' or enterprises' choice of organizational structure. Experience has shown that it is preferable to avoid taxes that create an incentive to promote stand alone research laboratories or solely contract research. Any tax scheme is required to be neutral, while providing adequate funds for investment and development.

Finally, there is a fundamental dependence of scientific and technological reform on legal and economic reform. In the legal sphere the central issue is the establishment of property rights of all forms (intellectual and material). The more quickly an appropriate

legal framework is in place, the more rapidly the transitional problems will disappear. In the economic sphere, it is clear that for rational technological assessment at the enterprise and national levels one needs the right prices (those that reflect the market determined supply and demand). Demonopolization is essential to allow competition to drive R&D investment. There are two separate benefits to demonopolization: (1) some competition will turn out to be better than no competition, and (2) in terms of increased size of total private resources invested in R&D, demonopolization and consequent competition will facilitate an improvement of the functioning of the selection process (the moving toward more desirable organizational forms). Labor mobility is of major importance in the economic sphere. S&T workers must be free to choose their employer and vice versa. To restrict labor mobility is to exclude a large fraction of the potential benefits of economic reform.

Plans for Further Research

The International Institute for Applied Systems Analysis and the USSR State Committee for Science and Technology agreed to continue their collaboration on the topic of *Research and Development Management in the Transition to a Market Economy.* Discussion concentrated on the most suitable approach for a productive, continuing activity.

The suggested procedure would include a series of workshops (approximately one every six months), each focussing on one or two central topics. This would allow ample time for careful individual study. It also facilitates the maintenance of the core group of experts, but leaves sufficient flexibility to invite additional scholars and managers depending on the subject matter. The Soviet contributions would provide statistical and analytical information, while the Western experts would largely use these as a basis for policy oriented contributions. All research would be within the framework of a longer term project that will enable closer ties, further extension of an international network of scholars for each particular area, broadening existing collaboration, and flexibility to accommodate newly arising issues. Furthermore, IIASA would organize *Advisory Committees* to assist in preparation.

The potential topics of interest now include national science and technology policy, modes of organizing industrial research and development, transformation of military S&T capabilities to civilian purposes and activities, comparative analysis of intellectual property rights, restructuring of basic science research institutes, technology assessment, S&T indicators and statistics, and the importance of foreign technology and other assistance. Professor Levin and Dr. Glaziev, the co-leaders of the activities, are presently shaping plans that include narrowing the scope and selecting topics for more intensive investigation.

Appendix

Conference Program

R & D Management in the Transition to a Market Economy

Moscow, July 13--15, 1991

Session 1: July 13, 10:00---14:00

R & D IN THE SOVIET ECONOMY

Drs. D. Piskunov and B. Saltykov, USSR Academy of Sciences Analytical Center, *Transformation of Basic Structures and Operating Mechanisms of Soviet Science.*

Discussant: Dr. Luc Soete, Maastricht Economic Research Institute on Innovation and Technology (MERIT).

Dr. B. Motorygin, USSR Committee for Science and Technology, and Dr. S. Glaziev, CEMI, *Economic Reform Impact on Soviet Research and Development.*

Discussant: Professor Richard Nelson, Columbia University.

Drs. L. Gokhberg and L. Mindely, Center for Soviet Science Statistics, *Soviet R & D Resources: Basic Characteristics.*

Discussant: Dr. Ben Martin, Science Policy Research Unit (SPRU), University of Sussex.

Session 2: July 13, 15:00---19:00

CASE STUDIES OF SOVIET R & D

Drs. Aizatulin and Kara-Murza, USSR Academy of Sciences Analytical Center, *The State and Organization of Soviet Science: The Case of Chemistry.*

Discussant: Professor Franz Moser, Technical University, Graz.

Drs. A.A. Nikitin and V.G. Bobylyov, Central Research Institute of Metallurgy, *Organizational Setup and Implementation of Applied R & D Projects in Metallurgy.*

Discussant: Professor Merton J. Peck, Yale University.

Dr. L. Malkov, CEMI, *Survivability of the Soviet R & D Sector: Computer Industry Case Study*, and *Eight Shifts in the Soviet Software Industry and the Future of the Computer Industry.*

Discussant: Professor Richard Levin, Yale University.

Drs. B.D. Yurlov, A.P. Sorokin, G.I. Sklyar, and I.V. Gonnov, USSR Committee for Science and Technology, *Perspectives on the Development of Regional Scientific Centers: The Town of Obninsk.*

Discussant: Dr. Thomas Richardson, Yale University.

Session 3: July 14, 10:00---14:00

TECHNOLOGICAL CHANGE IN THE SOVIET UNION

Drs. A. I. Ageev and D. V. Kuzin, *Responsiveness of Soviet Economy to Scientific and Technical Innovations: Comparisons with World Experience.*

Discussant: Professor Richard Nelson, Columbia University.

Dr. Kosals, Center for Research on Economic Transformations, *R & D Organization and Innovation in Industry in the Transition to Market.*

Discussant: Dr. Ben Martin, Science Policy Research Unit (SPRU), University of Sussex.

Drs. S. Kiselev and A. Voskoboy, USSR Committee on Science and Technology, *International Transfer of Technology.*

Discussant: Professor Akira Goto, Hitotsubashi University.

Drs. G. Mikerin and O. Kozlova, Ministry of Industry, Russian Republic, *Technological Assessment Problems in the Transition to Market Economy*, and
Drs. Y. Petrov and A. Kiselev, Institute of Economics and Industrial Engineering, *Technological Niches and Economic Policy.*

Discussant: Dr. Otto Keck, European University Institute.

Session 4: July 14, 15:00---19:00

PROSPECTS FOR RESTRUCTURING THE INSTITUTIONS OF TECHNOLOGICAL CHANGE

Professor Y.N. Kulichkov, *Defense Research and Designing Institutes in the State's Program of Conversion.*

Discussant: Professor Merton J. Peck, Yale University.

Dr. Y.V. Yakovets, National Economy Academy, *Technological Crisis and Conversion of Military Industry.*

Discussant: Dr. Roger Levien, Xerox Corporation.

Professor A.B. Vengerov and Dr. A.A. Alexandrov, USSR Committee on Science and Technology, *Legal Support of Innovation Activity.*

Discussant: Professor Alvin Klevorick, Yale University.

Dr. S. Glaziev, CEMI, *Prospects of Soviet R & D Restructuring.*

Discussant: Professor Richard Levin, Yale University.

Session 5: July 15, 10:00--14:00

DISCUSSION OF PLANS FOR FURTHER RESEARCH

R & D Management in the Transition to a Market Economy
Moscow, July 16, 1991
Program on
National Systems of Research and Development

Professor Richard Nelson, Columbia University,
National Systems of Technological Innovation: A Comparison (based on a forthcoming study of 15 nations).

Dr. Luc Soete, Maastricht Economic Research Institute on Innovation and Technology,
International Technological Competition and Cooperation (based on a recent report to the OECD).

Professor Richard Levin, Yale University,
R & D in the United States of America (with special reference to the problem of appropriability).

Professor Akira Goto, Hitotsubashi University, and Professor Merton J. Peck, Yale,
R & D in Japan (with special reference to administrative guidance of the private sector and the importation of foreign technology).

Dr. Ben Martin, Science Policy Research Unit, University of Sussex,
R & D in the United Kingdom (with special reference to the organization of basic science).

Dr. Otto Keck, European University Institute,
R & D in Germany (with special reference to the mix of public and private sector activities).

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R & D Management in the Transition to a Market Economy

Moscow, July 13--15, 1991

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